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ABSTRACT

This Third International Mathematics and Science Study (TIMSS), carried out in 1995, collected information about pupils' knowledge and understanding of mathematics and science, mathematics and science curricula, and teaching and learning practices. Data collection instruments included tests in mathematics and science and questionnaires completed by schools, teachers, and pupils. This report summarizes the TIMSS results for secondary 1 and secondary 2 pupils (mostly 13-year-olds) in Scotland. Results are reported in two sections: mathematics and science. Each section includes performance, examples of test items, and Scottish features and international comparisons. Conclusions drawn include: Scotland's performance relative to the other TIMSS countries was poor, especially in mathematics; of the Pacific rim countries Singapore, Korea, Japan, and Hong Kong did very well in mathematics, but the performance of Thailand was poorer; the gain in performance between secondary 1 and secondary 2 was quite large in Scotland in both mathematics and science, and Scottish pupils' performance was better on certain aspects of mathematics and science; in almost all countries boys did better than girls in science and the difference was significant; pupils experienced more mathematics teaching on average in Scotland but less than average in science; and more pupils were absent on a typical day in Scotland than in any other country. (JRH)

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Third International Mathematics
and Science Study (TIMSS)

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Achievements of Secondary 1 and Secondary 2 Pupils in Mathematics and Science

Third International Mathematics
and Science Study (TIMSS)

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1 Introduction

The Third International Mathematics and Science Study (TIMSS), carried out in 1995, is the latest in a series of international studies carried out by the International Association for the Evaluation of Educational Achievement (IEA). Previously, separate international studies were carried out in the two subjects – in 1964 and 1980-82 in mathematics and in 1970-71 and 1983-84 in science. These studies were of the attainment of 10, 13 and 14 year olds and on pupils in their final year at school. The International Assessment of Educational Progress (IAEP) also carried out a study of attainment in mathematics and science of 9 and 13 year olds in 1991 in 20 countries.

Scotland is one of over 40 countries which participated in TIMSS, including most of the EU member states, other major English speaking countries, leading Pacific rim countries and Eastern European countries.

The main aims of TIMSS were to collect information about:

- ☐ pupils' knowledge and understanding of mathematics and science;
- ☐ mathematics and science curricula;
- ☐ teaching and learning practices.

In order to achieve these aims, pupils were administered tests in mathematics and science, and questionnaires were completed by schools, teachers and pupils.

This report summarises the TIMSS results for secondary 1 and secondary 2 pupils. A further report will be published describing the results for primary 4 and primary 5 pupils.

Sampling

Sampling was a two stage process involving first the random selection of schools, then second the random selection of a class at each of the two grades containing most 13 year olds. In Scotland these grades were

secondary 1 and secondary 2. Details of the sampling procedure are available in the TIMSS Technical Report.

The TIMSS overall target sample of schools for each country was 150 but, due to the small size of some of our schools, the Scottish target was 153 schools. For the upper grade the school response rate was 83% and for the lower grade it was 84% when replacement schools were included. The target pupil samples were 3242 at the upper grade and 3360 at the lower grade and response rates of 88% and 90% respectively were obtained.

Scottish pupils at both grades were the third youngest of all the countries with the exception of Iceland and Greece. However, along with England, Australia, New Zealand and Kuwait, they had the most years of formal schooling.

Administration

The tests and questionnaires were mainly sent out to schools in April 1995. The tests were administered by the schools and were timed to allow the majority of pupils to complete them. The pupil questionnaire was not timed. Mathematics classes were selected to participate in the study, and their teachers and headteachers completed questionnaires. Questionnaires were also completed by most of the pupils' science teachers.

The pupil questionnaire asked about home background, attitudes towards mathematics and science and perceptions of lessons in these subjects. The teacher questionnaire asked about education, training and experience, how teachers divided their time between teaching and teaching related activities, teaching approaches, resources available and views on teaching and learning in mathematics and science. The questionnaire for schools asked for general background information, organisational features related to the teaching of mathematics and science, resources available and time devoted to these subjects.

Assessment instruments

The main assessments were in the form of written tests. Each pupil sat a test in one booklet, out of eight booklets in total, which contained mathematics and science tasks. In addition a performance assessment using practical tasks was carried out in some countries. In some countries the performance assessment was carried out with primary and secondary pupils but in Scotland only secondary 1 and secondary 2 pupils participated in the performance assessment. The performance assessment results will be reported elsewhere.

All tests contained a common core of tasks. The other tasks appeared in different versions of the tests. Tests were allocated to pupils in rotation so only a few pupils in each school took the same test. The total test battery consisted of 151 mathematics tasks and 135 science tasks. The tests were administered in two sessions taking 90 minutes in total.

The tasks included multiple choice questions, short answer questions and extended response questions. About one quarter of the tasks were in free response format. The reporting categories used in this report are:

Mathematics

- ☐ fractions and number sense
- ☐ geometry
- ☐ algebra
- ☐ data representation, analysis and probability
- ☐ measurement
- ☐ proportionality

Science

- ☐ earth science
- ☐ life science
- ☐ physics
- ☐ chemistry
- ☐ science and environment

The same tasks were used in all countries in order that comparisons on common curriculum areas could be made. However, a curriculum matching exercise was carried out which involved each country in defining what tasks were covered in their curriculum. A further analysis was then done for each country based on only these tasks to provide performance measures relevant to that country.

2.1 Performance in mathematics

This report compares the mathematics performance of Scottish pupils with that of pupils in other countries participating in TIMSS. The comparisons are made in terms of:

- ☐ overall mean scores
- ☐ mean scores in the six reporting categories
- ☐ mean scores on the tasks identified in the curriculum matching exercise
- ☐ performance on selected individual tasks

The grades selected for testing in TIMSS were the two grades containing the greatest number of 13 year olds. In Scotland these grades were secondary 1 and secondary 2. Separate mean scores were calculated for pupils at each grade and median scores for pupils who were aged 13 at the time of testing. Where appropriate, comparisons are made with the 1991 results from IAEP. Unless otherwise stated, 39 countries took part in the lower grade tests and 41 in the higher grade tests. It should be noted that Scottish pupils were younger on average than the pupils in all other countries except for Iceland and Greece and that at the time of testing they had at least one extra year at school compared to all countries except for England, Australia, New Zealand and Kuwait.

Overall mean scores

The international scores for the lower and upper grades in all countries are presented in Table 1. These are scaled scores calculated using plausible values procedures which are explained in the TIMSS Technical Report. The overall mean score for the lower grade was 484, compared to Scotland's 463, and for the upper grade it was 513, compared to Scotland's 498. Overall Scotland's ranking was 26th out of 39 countries at the lower grade and 28th out of 41 at the upper grade, including countries which did not meet TIMSS sampling criteria. However, comparisons with countries which did not meet TIMSS sampling criteria should be treated with caution.

Table 1 Mean scaled scores in mathematics for each grade

Country	Mean Score Lower Grade	Mean Score Upper Grade
Singapore	601	643
Korea	577	607
Japan	571	605
Hong Kong	564	588
Belgium (Fl)*	558	565
Czech Republic	523	564
Netherlands	516	541
Bulgaria	514	540
Austria	509	539
Slovak Republic	508	547
Belgium (Fr)*	507	526
Switzerland	506	545
Hungary	502	537
Russian Federation	501	535
Ireland	500	527
Australia	498	530
Canada	494	527
France	492	538
Sweden	477	519
USA	476	500
England	476	506
New Zealand	472	508
Scotland	463	498
Latvia	462	493
Norway	461	503
Iceland	459	487
Spain	448	487
Cyprus	446	474
Lithuania	428	477
Portugal	423	454
Iran	401	428
<i>Countries not meeting TIMSS sampling criteria</i>		
Slovenia	498	541
Thailand	495	522
Israel	N/A	522
Germany	484	509
Denmark	465	502
Romania	454	482
Greece	440	484
Kuwait	N/A	392
Columbia	369	385
South Africa	348	354
* Belgium (Fl) is Flemish speaking Belgium and Belgium (Fr) is French speaking Belgium.		

The Pacific rim countries did very well in mathematics with Singapore, Korea, Japan and Hong Kong leading the performance table. The exception was Thailand which did not perform significantly better than Scotland at the upper grade.

Of the European countries, Belgium and Switzerland did particularly well. Performance in Norway, Denmark and Iceland at the lower grade and Greece, Germany, England, Norway, Denmark, Spain and Iceland at the upper grade was not significantly different from Scotland. Greece, Portugal and Spain at the lower grade and Portugal at the higher grade were significantly outranked by Scotland.

Nine of the Eastern European countries participated in TIMSS and the Czech and Slovak Republics did particularly well. All of them, except Latvia, Romania and Lithuania, significantly outranked Scotland at both grades, but only in the case of Lithuania was Scotland significantly ahead.

Other English speaking countries – Australia, Canada, New Zealand and the USA – were all middle range performers but only Australia and Canada significantly outranked Scotland at both grades. In the case of the USA and New Zealand the differences were not significant.

Table 2 shows Scotland's position relative to other countries. Eight countries at the lower grade and seven countries at the upper grade were significantly worse than Scotland and 21 countries at the lower grade and 19 at the upper grade were significantly better than Scotland.

All of the countries participating in both IAEP and TIMSS which were ranked higher than Scotland in TIMSS were also ranked higher in IAEP. Three countries that were ranked lower than Scotland in IAEP were ranked higher in TIMSS. Ireland and Slovenia were significantly better than Scotland, and the USA was better but not significantly.

Difference between the lower and upper grades

The same tests were taken by each grade and the

difference in scores between the lower and upper grade gives an indication of the gains made in this year. In Scotland the difference in score between the lower grade and the upper grade was 36 score points, which was the 13th greatest difference of all countries but starting from a relatively low base. Over all countries the differences averaged 29 score points, varying from 7 (in South Africa) to 49 (in Lithuania).

If we look at the mean difference in scores in the different aspects of mathematics in Scotland, the difference was higher for algebra and measurement and lower for fractions and number sense, geometry and proportionality.

If we regard the average gain of 29 score points as a year's progress, then the pupils of 19 countries at the lower grade and 16 countries at the upper grade were over a year ahead of Scottish pupils.

Benchmarks of performance

If we regard the mean scores over all countries for the top 10% of pupils, the top 25% and the top 50% as benchmarks of performance, we can compare them with the percentage of pupils in each country reaching these benchmarks. At the lower grade, 4% of Scottish pupils attained the 10% benchmark, 15% attained the 25% benchmark and 43% attained the 50% benchmark and Scotland was ranked 23rd, 25th and 26th respectively. At the upper grade, the equivalent percentages were 5%, 17% and 44% and Scotland was ranked 24th, 26th and 28th respectively.

These rankings indicate that the highest performing Scottish pupils did marginally better than lower performing ones relative to other countries.

Curriculum matching exercise

In the curriculum matching analysis, the TIMSS task bank was scanned by each country to identify the tasks which were within their curriculum. The performance of pupils was then assessed for each country on the basis of the tasks judged to be within the curriculum of each.

Table 2 Scotland's position relative to other countries

	Lower Grade	Higher Grade
Countries significantly higher than Scotland	Australia, Austria, Belgium, Bulgaria, Canada, Czech Republic, France, Germany, Hong Kong, Hungary, Ireland, Japan, Korea, Netherlands, Russian Federation, Singapore, Slovak Republic, Slovenia, Sweden, Switzerland, Thailand	Australia, Austria, Belgium, Bulgaria, Canada, Czech Republic, France, Hong Kong, Hungary, Ireland, Japan, Korea, Netherlands, Russian Federation, Singapore, Slovak Republic, Slovenia, Switzerland
No significant difference from Scotland	Denmark, England, Iceland, Latvia, New Zealand, Norway, Romania, USA	Denmark, England, Germany, Greece, Iceland, Israel, Latvia, New Zealand, Norway, Romania, Spain, Thailand, USA
Significantly lower than Scotland	Columbia, Cyprus, Greece, Iran, Lithuania, Portugal, Spain, South Africa	Columbia, Cyprus, Iran, Lithuania, Kuwait, Portugal, South Africa

The tasks identified as being within Scotland's curriculum had total unscaled scores of 76 at the lower grade and 125 at the upper grade, compared to scores of 162 for all of the TIMSS tasks at both grades. Scotland's scores on the tasks judged to be within its curriculum were 54 and 55 (out of 76 and 125 respectively) for the two grades and her rankings were 24th and 26th respectively for the lower and upper grades. This was only a small improvement on Scotland's ranking based on performance on all of the tasks, which seems to indicate that the TIMSS tests were fair in relation to the Scottish curriculum.

Performance of 13 year olds

In 33 of the TIMSS countries the percentage of 13 year olds in the two grades tested exceeded 75%. For these countries the median scores were calculated as the best indicator of performance. Scotland's ranking in relation to these countries was 18th, which was an improvement on the overall grade rankings for Scotland due to the younger average age of the Scottish pupils compared to almost all other countries.

Performance in different aspects of mathematics

The performance of Scottish pupils varied in the different aspects of mathematics covered by the tests. These are exemplified in Table 3 by showing Scotland's rankings in the different aspects. Scotland's performance was relatively good on geometry and data representation, analysis and probability and relatively poor on fractions and number sense, algebra and proportionality.

Gender and performance in mathematics

At the lower grade, boys did better than girls in 31 out of 38 countries, but the differences were only statistically significant in six cases, all with boys better than girls. At the upper grade boys did better than girls in 30 out of 39 countries but the differences were only statistically significant in eight cases, all with boys better than girls.

In Scotland, at both grades, boys' overall performance was better than girls' by three score points at the lower grade and 16 score points at the upper grade but the differences were not statistically significant. If we look at the different aspects of

mathematics, boys seemed to perform better than girls in measurement and proportionality and girls marginally better than boys in algebra, but the differences were not statistically significant.

Table 3 Scotland's rankings on aspects of mathematics

Aspect	Lower grade ranking*	Upper grade ranking
Fractions and number sense (51 items)	27	28
Geometry (23 items)	22	25
Algebra (27 items)	29	30
Data representation, analysis and probability (21 items)	23	21
Measurement (18 items)	27	25
Proportionality (11 items)	28	28
* Out of 38 countries		

2.2 Examples of mathematics test items

Fractions and number sense

Example 1: Subtraction problem with whole numbers

Subtract: 6000
-2369

- A. 4369
- B. 3742
- C. 3631
- D. 3531

Scotland's performance

	Percentage correct	International ranking
Lower grade	75	34
Upper grade	72	35

Example 2: Rate of fuel consumption

A car has a fuel tank that holds 35 L of fuel. The car consumes 7.5 L of fuel for each 100 km driven. A trip of 250 km was started with a full tank of fuel. How much fuel remained in the tank at the end of the trip?

- A. 16.25 L
- B. 17.65 L
- C. 18.75 L
- D. 23.75 L

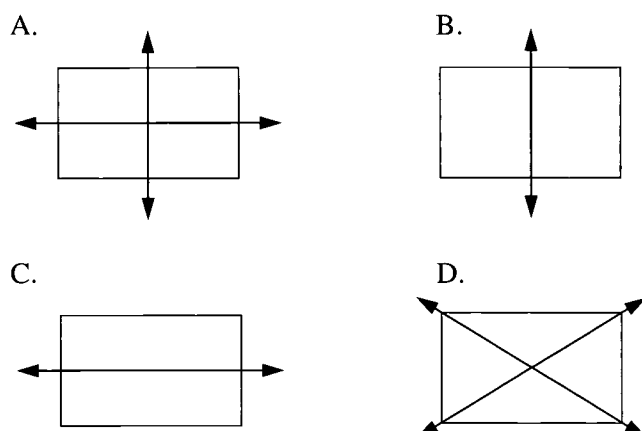
Scotland's performance

	Percentage correct	International ranking
Lower grade	32	24
Upper grade	38	18

Geometry

Example 3: Lines of symmetry

Which shows all of the lines of symmetry for a rectangle?

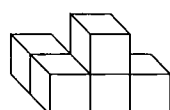


Scotland's performance

	Percentage correct	International ranking
Lower grade	83	2
Upper grade	86	1

Example 4: Rotated 3-dimensional figure

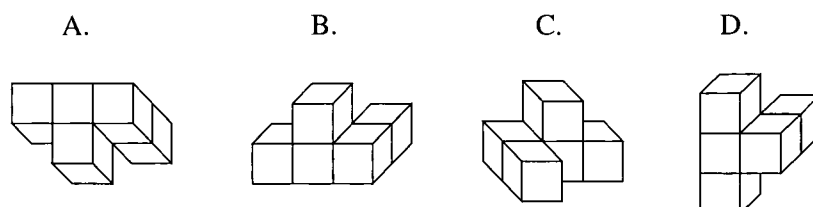
This figure will be turned to a different position.



Scotland's performance

	Percentage correct	International ranking
Lower grade	65	22
Upper grade	72	22

Which of these could be the figure after it is turned?



Algebra

Example 5: Equivalent algebraic expressions

If m represents a positive number, which of these is equivalent to $m + m + m + m$?

- A. $m + 4$
- B. $4m$
- C. m^4
- D. $4(m + 1)$

Scotland's performance		
	Percentage correct	International ranking
Lower grade	53	13
Upper grade	55	27

Example 6: Solve linear equation for x

If $3(x + 5) = 30$, then $x =$

- A. 2
- B. 5
- C. 10
- D. 95

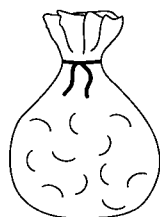
Scotland's performance		
	Percentage correct	International ranking
Lower grade	40	34
Upper grade	62	31

Data representation, analysis and probability**Example 7: Chance of picking red marble**

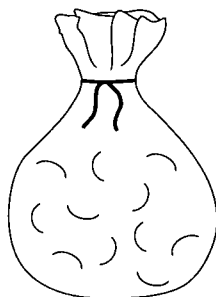
There is only one red marble in each of these bags. Without looking in the bags, you are to pick a marble out of one of the bags. Which bag would give you the greatest chance of picking the red marble?



10 marbles



100 marbles



1000 marbles

- A. The bag with 10 marbles
- B. The bag with 100 marbles
- C. The bag with 1000 marbles
- D. All bags would give the same chance.

Example 8: Number of red cube faces

Each of the six faces of a certain cube is painted either red or blue. When the cube is tossed, the probability of the cube landing with a red face up is $\frac{2}{3}$. How many faces are red?

- A. One
- B. Two
- C. Three
- D. Four
- E. Five

Scotland's performance

	Percentage correct	International ranking
Lower grade	78	18
Upper grade	82	17

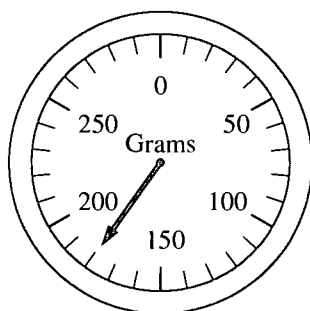
Scotland's performance

	Percentage correct	International ranking
Lower grade	36	24
Upper grade	48	20

Measurement

Example 9: Weight shown on scale

What is the weight (mass) shown on the scale?

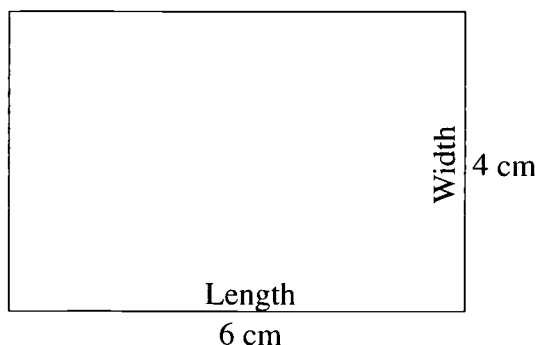


- A. 153 g
- B. 160 g
- C. 165 g
- D. 180 g

Scotland's performance

	Percentage correct	International ranking
Lower grade	86	20
Upper grade	92	11

Example 10: New rectangle : draw from ratio of sides



In the space below, draw a new rectangle whose length is one and one half times the length of the rectangle above, and whose width is half the width of the rectangle above. Show the length and width of the new rectangle in centimeters on the figure.

Scotland's performance

	Percentage correct	International ranking
Lower grade	19	23
Upper grade	27	24

Proportionality

Example 11: Ratio of red paint in mixture

To mix a certain color of paint, Alana combines 5 liters of red paint, 2 liters of blue paint, and 2 liters of yellow paint. What is the ratio of red paint to the total amount of paint?

- A. $\frac{5}{2}$
- B. $\frac{5}{4}$
- C. $\frac{5}{4}$
- D. $\frac{5}{9}$

Scotland's performance

	Percentage correct	International ranking
Lower grade	38	16
Upper grade	38	23

Example 12: Number of girls from boy/girl ratio

A class has 28 students. The ratio of girls to boys is 4 : 3. How many girls are in the class?

Answer _____

Scotland's performance

	Percentage correct	International ranking
Lower grade	26	20
Upper grade	37	19

2.3 *Scottish features and international comparisons in mathematics*

Characteristics of the schools	The average number of class teachers per school was 68 to 69.	Only two countries had a higher number of class teachers per school.
	67% of the teachers had been at the school for five years or more.	This was about average.
	The number of pupils per school was over 950.	This was above average.
	On average 109 to 110 computers were available for teachers and pupils in each school.	This was more than in any other country.
	The average class size was 26.	This was slightly above average.
	Over 9% of pupils were absent on a typical day.	This was higher than in any other country.
Characteristics of mathematics teachers	Between 55% and 57% of teachers were male.	This was somewhat higher than in most countries.
	On average teachers had been teaching for 15 to 16 years.	This was slightly lower than average.
	Teachers had nearly 22 hours per week for teaching mathematics.	This was only exceeded in three countries.
	Teachers spent a further 5.6 hours per week on tasks related to the teaching of mathematics.	This was slightly lower than average.
Mathematics teaching practices	Well over 90% of teachers used a textbook in class.	This was somewhat less than in most countries.
	55% of teachers used the textbook for over three quarters of their teaching time.	This was considerably higher than in most countries.
	Over 80% of teachers said that pupils had access to calculators during lessons almost all the time.	This was considerably more than in most countries.
	23 to 24 % of teachers set mathematics homework never or less than once a week.	This was a much higher percentage than in almost all other countries.

Mathematics teaching practices (cont'd)	About 30% of teachers said differences in the academic ability of pupils limited their teaching a great deal.	This was considerably higher than in most countries.
	Over 20% of teachers said a high pupil-teacher ratio limited their teaching a great deal.	This was slightly higher than average.
	Over 98% of schools offered remedial teaching in mathematics.	This was more than in most countries.
	63 to 64% of schools offered enrichment for more able pupils.	This was slightly above average.
	On average pupils spent 218 minutes on mathematics per week.	This was slightly higher than average.
	82 to 85% of pupils said the teacher almost always or pretty often showed them how to do problems.	This was lower than in most countries.
	At the lower grade 46% of pupils said they copied out notes from the board almost always or pretty often and this increased to over 60% at the upper grade.	This was considerably lower than in most countries.
	Over 90% of the pupils used worksheets or text books alone almost always or pretty often.	This was more than in any other country.
	19 to 25% of pupils undertook mathematics projects almost always or pretty often.	This was just about average.
	Nearly 70% of the lower grade and over 80% of the upper grade used calculators in class almost always or pretty often.	This was higher than in most countries.
Characteristics of pupils	About 15% of pupils spent no time on studying or doing mathematics homework and a further 70% spent less than one hour per day on it.	This was a higher percentage than in all countries bar two.
	Less than 80% had their father living with them.	This was lower than in most countries.
	Just over 10% had between 0 and 10 books in their home.	This was a higher percentage than in most countries.
	Nearly a quarter had over 200 books in their home.	This was about average.

Characteristics of pupils (cont'd)	34 to 38% said they spent no time reading books.	This was higher than in most countries.
	About 40% spent three or more hours per day watching TV or videos.	This was more than in most countries.
	Less than 10% spent three hours or more per day playing computer games.	This was more than in almost all other countries.
	Nearly 90% had a computer at home.	This was more than any country other than England.
	Over 97% had a calculator.	This was about average.
Pupils' views	About three quarters of pupils liked mathematics or liked it a lot.	This was slightly higher than average.
	98% agreed or agreed strongly that their mother wanted them to do well in mathematics.	This was slightly above average.
	Over 98% of pupils agreed or agreed strongly that it was important for them to do well in mathematics.	This was slightly above average.
	Nearly 90% said they needed to do well in mathematics to get the job they wanted.	This was higher than in most other countries.

3.1 Performance in science

Comparisons are made between the science performance of Scottish pupils and pupils in other countries which participated in TIMSS. Some of these comparisons are of scaled scores derived using plausible values procedures which are described in the TIMSS Technical Report. The comparisons are made in terms of:

- ☐ overall mean scores
- ☐ mean scores in the five reporting categories
- ☐ mean scores on tasks identified in the curriculum matching exercise
- ☐ performance on selected tasks

Separate mean scores are shown for secondary 1 and secondary 2. (TIMSS also calculated median scores for pupils aged 13 at the time of testing.) Where appropriate, comparisons are made with results from IAEP in 1991.

Overall mean scores

The international mean scores for the lower and upper grades in all countries are presented in Table 4. The mean for the lower grade was 479, compared to Scotland's 468, and for the upper grade it was 516, compared to Scotland's 517. Overall, Scotland's ranking was 25th out of 38 countries at the lower grade and 25th out of 40 countries at the upper grade, including those countries which did not meet TIMSS sampling criteria.

Three of the Pacific rim countries did well, two of them, Singapore and Korea, being ranked (on lower grade scores) first and second and one, Japan, being ranked fourth. Hong Kong and Thailand were ranked 16th and 18th respectively (on lower grade scores).

Of the European countries, Belgium (Fl), Austria, Netherlands and England did particularly well. Performance in Norway, Spain and Iceland at the lower grade and Ireland, Sweden, Germany, Norway,

Table 4 Mean scaled scores in science at each grade

Country	Mean Score Lower Grade	Mean Score Upper Grade
Singapore	545	607
Korea	535	565
Czech Republic	533	574
Japan	531	571
Bulgaria	531	565
Belgium (Fl)	529	550
Austria	519	558
Hungary	518	554
Netherlands	517	560
England	512	552
Slovak Republic	510	544
USA	508	534
Australia	504	545
Canada	499	531
Hong Kong	495	522
Ireland	495	538
Sweden	488	535
Russian Federation	484	538
Switzerland	484	522
Norway	483	527
New Zealand	481	525
Spain	477	517
Scotland	468	517
Iceland	462	494
France	451	498
Belgium (Fr)	442	471
Iran	436	470
Latvia	435	485
Portugal	428	480
Cyprus	420	463
Lithuania	403	476
<i>Countries not meeting TIMSS sampling criteria</i>		
Slovenia	530	560
Germany	499	531
Thailand	493	525
Israel	N/A	524
Romania	452	486
Greece	449	497
Denmark	439	478
Kuwait	N/A	430
Colombia	376	411
South Africa	317	326
* Belgium (Fl) is Flemish speaking Belgium and Belgium (Fr) is French speaking Belgium.		

Switzerland and Spain at the upper grade was not significantly different from Scotland. Scotland significantly outranked France, Belgium (Fr), Portugal, Denmark and Greece at the lower grade and Belgium (Fr), Denmark, France, Greece, Iceland and Portugal at the upper grade.

Four of the Eastern European countries did well, the Czech Republic, Bulgaria, Slovenia and Hungary, and the Slovak Republic and the Russian Federation were ranked 12th and 21st respectively at the lower grade. Scotland only significantly outranked Latvia and Lithuania at the lower grade and Latvia, Lithuania and Romania at the upper grade.

Other English speaking countries – Australia, Canada, New Zealand and the USA – were all middle range performers but all significantly outranked Scotland except for New Zealand at the lower grade, which was not significantly different, and the USA, Canada and New Zealand at the upper grade.

Table 5 shows Scotland's position relative to other countries. Scotland was significantly better than 11 countries at the lower grade and 14 countries

at the higher grade and significantly worse than 21 countries at the lower grade and 14 countries at the upper grade.

All of the countries participating in both TIMSS and the IAEP which were ranked higher than Scotland in IAEP were also higher in TIMSS, other than England and Ireland which were poorer than Scotland in IAEP and were better than Scotland in TIMSS.

Differences between the lower and upper grades

The same tests were taken by each grade and the difference in scores gives an indication of the gains made in this year. In Scotland the difference was 49 score points which was the 6th highest of all countries but starting from a low base. The differences averaged 37 score points over all countries and varied from 9 (in South Africa) to 73 (in Lithuania).

The mean difference in Scotland was greater in chemistry and lower in earth science and in physics.

Table 5 Scotland's position relative to other countries

	Lower Grade	Upper Grade
Countries significantly higher than Scotland	Australia, Austria, Belgium (Fl), Bulgaria, Canada, Czech Republic, England, Germany, Hong Kong, Hungary, Ireland, Japan, Korea, Netherlands, Singapore, Slovak Republic, Slovenia, Sweden, Switzerland, Thailand, USA	Australia, Austria, Belgium (Fl), Bulgaria, Czech Republic, England, Hungary, Japan, Korea, Netherlands, Russian Federation, Singapore, Slovak Republic, Slovenia,
No significant difference from Scotland	Iceland, New Zealand, Norway, Romania, Russian Federation, Spain	Canada, Germany, Hong Kong, Ireland, Israel, New Zealand, Norway, Spain, Sweden, Switzerland, Thailand, USA
Significantly lower than Scotland	Belgium (Fr), Colombia, Cyprus, Denmark, France, Greece, Portugal, Iran, Latvia, Lithuania, South Africa	Belgium (Fr), Colombia, Cyprus, Denmark, France, Greece, Iceland, Iran, Kuwait, Latvia, Lithuania, Portugal, Romania, South Africa

If we regard the average difference of 37 score points as a year's progress, the Scottish pupils were more than a year behind 13 other countries at the lower grade and eight other countries at the upper grade.

Benchmarks of performance

If we regard the mean scores over all countries for the top 10%, the top 25% and the top 50% of pupils as benchmarks of performance, we can compare the percentage of pupils in each country reaching these benchmarks. At the lower grade, 6% of Scottish pupils achieved the 10% benchmark, 19% the 25% benchmark and 42% the 50% benchmark and Scotland's rankings were 21st, 24th and 25th respectively. At the upper grade, 9% of Scottish pupils achieved the 10% benchmark, 23% the 25% benchmark and 48% the 50% benchmark and Scotland's rankings were 19th, 22nd and 25th respectively. This indicates that Scotland's higher performing pupils do slightly better than lower performing ones relative to other countries.

Curriculum matching exercise

The tasks rated as being in Scotland's curriculum had score points of 50 for the lower grade and 97 for the upper grade compared to 146 score points for all the tasks. Scotland's scores on the tasks within its

curriculum were 53% at the lower grade, where its ranking was 16th (out of 37) and 56% at the upper grade, where its ranking was 23rd (out of 39). The ranking for the lower grade is a considerable improvement on Scotland's ranking on all tasks but there was only a very small improvement at the upper grade.

Performance of 13 year olds

In 33 of the TIMSS countries the percentage of 13 year olds in the two grades tested exceeded 75%. For these countries the median scores were calculated as the best indicator of performance. Scotland's ranking in these countries was 16th, which was an improvement on the overall grade rankings due to the younger average age of the Scottish pupils.

Performance in different aspects of science

The performance of Scottish pupils varied in different aspects of science covered by the tests. This can be best described by showing Scotland's rankings in the different aspects.

As might be expected, performance was similar at the two grades. Pupils did relatively well in physics and science and the environment and relatively poorly in life science.

Table 6 Scotland's ranking on aspects of science

Aspect	Lower grade ranking	Upper grade ranking
Earth science	25	27
Life science	28	27
Physics	17	17
Chemistry	22	22
Science and environment	15	15

Gender and performance in science

At the lower grade, boys performed better than girls in all countries and the differences were statistically significant in 26 of them. At the upper grade, boys were better than girls in all but two countries (Cyprus

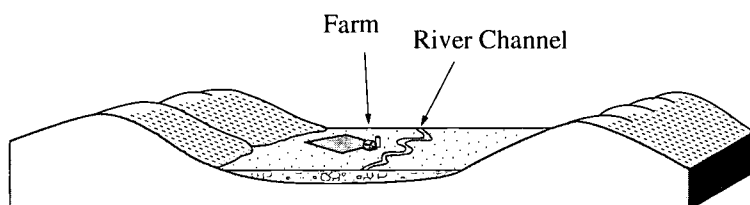
and Thailand) and the differences were significant in 28 of them. Boys were significantly better at both grades in Scotland overall and in two aspects of science at both grades, earth science and chemistry.

3.2 Examples of science test items

Earth science

Example 1: River on plain

The diagram shows a river flowing through a wide plain. The plain is covered with several layers of soil and sediment.



Write down one reason why this plain is a good place for farming.

Scotland's performance

	Percentage correct	International ranking
Lower grade	77	19
Upper grade	81	20

Example 2: Ozone layer

Write down one reason why the ozone layer is important for all living things on Earth.

Scotland's performance

	Percentage correct	International ranking
Lower grade	29	31
Upper grade	42	30

Life science

Example 3: Chloroplasts in cells

What is the main function of chloroplasts in a plant cell?

- A. To absorb light energy and manufacture food.
- B. To remove waste materials by active transport.
- C. To manufacture chemical energy from food.
- D. To control the shape of the cell.

Scotland's performance		
	Percentage correct	International ranking
Lower grade	40	31
Upper grade	49	24

Example 4: Heart rate changes

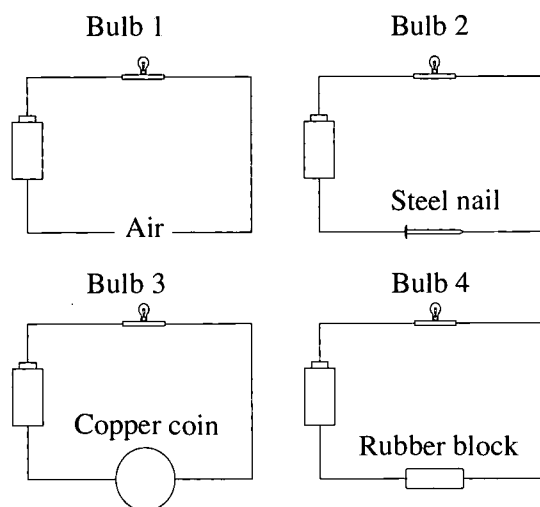
Suppose you want to investigate how the human heart rate changes with changes in activity. What materials would you use and what procedures would you follow?

Scotland's performance		
	Percentage correct	International ranking
Lower grade	14	7
Upper grade	25	5

Physics

Example 5: Light bulb in circuit

The following diagrams show a flashlight battery and a bulb connected by wires to various substances.



Which of the bulbs will light?

- A. 1 and 2 only
- B. 2 and 3 only
- C. 3 and 4 only
- D. 1, 2, and 3 only
- E. 2, 3, and 4 only

Scotland's performance

	Percentage correct	International ranking
Lower grade	70	21
Upper grade	82	15

Example 6: Sound in space

The crews of two boats at sea can communicate with each other by shouting. Why is it impossible for the crews of two spaceships a similar distance apart in space to do this?

- A. The sound is reflected more in space.
- B. The pressure is too high inside the spaceships.
- C. The spaceships are travelling faster than sound.
- D. There is no air in space for the sound to travel through.

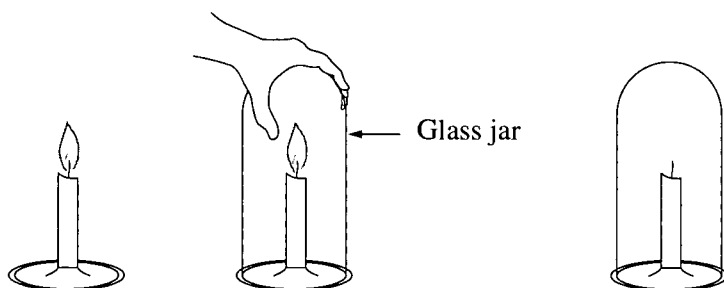
Scotland's performance

	Percentage correct	International ranking
Lower grade	68	19
Upper grade	77	8

Chemistry

Example 7: Glass over candle flame

When a glass jar is placed over a lighted candle, the flame goes out.



Why does this happen?

Scotland's performance

	Percentage correct	International ranking
Lower grade	79	32
Upper grade	93	14

Example 8: Molecules, atoms and cells

The words *cloth*, *thread*, and *fiber* can be used in the following sentence: *cloth* consists of *threads* which are made of *fiber*.

Use the words *molecules*, *atoms*, and *cells* to complete the following sentence:

_____ consist of
 _____ which are made of

Scotland's performance

	Percentage correct	International ranking
Lower grade	21	15
Upper grade	27	24

Science and environment

Example 9: Liquid evaporation experiment

A cupful of water and a similar cupful of gasoline were placed on a table near a window on a hot sunny day. A few hours later it was observed that both the cups had less liquid in them but that there was less gasoline left than water. What does this experiment show?

- A. All liquids evaporate.
- B. Gasoline gets hotter than water.
- C. Some liquids evaporate faster than others.
- D. Liquids will only evaporate in sunshine.
- E. Water gets hotter than gasoline.

Scotland's performance		
	Percentage correct	International ranking
Lower grade	67	10
Upper grade	72	11

Example 10: Acid rain

One of the principal causes of acid rain is

- A. waste acid from chemical factories being pumped into rivers.
- B. acid from chemical laboratories evaporating into the air
- C. gases from burning coal and oil dissolving in water in the atmosphere
- D. gases from air conditioners and refrigerators escaping into the atmosphere

Scotland's performance		
	Percentage correct	International ranking
Lower grade	28	19
Upper grade	32	18

3.3 *Scottish features and international comparisons in science*

Characteristics of science teachers	63 to 64% of teachers were males.	This was considerably higher than in most countries.
	On average teachers had been teaching for 15 to 16 years.	This was about average.
Science teaching practices	On average teachers taught science to their class for just under 155 minutes per week.	This was longer than average.
	84% of teachers used a textbook in their classes.	This was less than in most other countries.
	16 to 27% of teachers used the textbook for over three quarters of their teaching time.	This was slightly above average.
	44 to 49% of the teachers allowed access to calculators in class almost all the time.	This was more than average.
	Nearly 85% of pupils said their teacher showed them how to do problems almost always or pretty often.	This was higher than average.
	71 to 75% of pupils said they copied notes from the board almost always or pretty often.	This was lower than average.
	44 to 54% of pupils said they did science projects almost always or pretty often.	This was more than average.
	68 to 71% of pupils used worksheets or textbooks almost always or pretty often.	This was more than all countries bar one.
	Over 20% of pupils spent no time studying or doing science homework and nearly 70% spent less than one hour per week on it.	These were higher percentages than most other countries.
Pupils' views	Over 90% of pupils agreed or agreed strongly that their mothers thought it important to do well in science.	This was about average.

Pupils' views (cont'd)	60 to 70% of pupils wanted to do well in science to please their parents.	This was just above average.
	About 80% of pupils enjoyed learning science.	This was higher than average.
	Just over a quarter of pupils thought science was a boring subject.	This was higher than average.
	59 to 64% of pupils said they needed science to get the job they wanted.	This was above average.

4 Conclusions

- ❑ Scotland's performance relative to the other TIMSS countries was poor, particularly in mathematics. There appeared to have been some deterioration since the IAEP study in 1991.
- ❑ Of the Pacific rim countries, Singapore, Korea, Japan and Hong Kong did very well in mathematics, but the performance of Thailand was poorer. Performance was generally good in science, but Hong Kong and Thailand performed less well.
- ❑ The gain in performance between secondary 1 and secondary 2 was quite large in Scotland in both mathematics and science.
- ❑ Scotland's higher performing pupils tended to do slightly better relative to pupils in other countries, but this was not pronounced.
- ❑ Because Scottish pupils were among the youngest in the study, the median performance of 13 year olds was somewhat better than the performance of the two grades relative to other countries.
- ❑ Scottish pupils' performance was better on certain aspects of mathematics and science. In mathematics, geometry and data representation, analysis and probability were done relatively well. In science, physics and science and the environment were relatively well done.
- ❑ In most countries, boys performed better than girls in mathematics, but only in a few countries were the differences statistically significant. In Scotland, boys were better than girls but not significantly so.
- ❑ In almost all countries, boys did better than girls in science and in most the difference was statistically significant. In Scotland, boys did significantly better than girls.
- ❑ Pupils experienced more mathematics teaching on average in Scotland but less than average in science.
- ❑ In mathematics, calculators and computers were used more in Scotland than in most countries but their use in science was about average.
- ❑ More pupils were absent on a typical day in Scotland than in any other country.
- ❑ Less homework was set in mathematics and in science in Scotland than in almost all other countries.
- ❑ Scottish pupils watched more television and played computer games more than in most other countries.



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